SECTION 81

HULL MACHINERY

81.1 REFERENCES

(81A) **VOLUME V**, *OWNER - FURNISHED EQUIPMENT*

81.2 INTRODUCTION

This Section contains the Contractor Design and Provide general requirements for the Vessel's steering gear and deck machinery.

For WSF Fleet-wide Standardization purposes, End No. 1 of the Vessel shall always be considered the bow, and this designation shall delineate port and starboard, fore and aft wherever they are addressed in the Technical Specification.

81.3 GENERAL

Where practicable, all hull machinery shall be standard models and made by recognized marine equipment manufacturers. Deck machinery shall be furnished by one (1) manufacturer.

All machinery shall conform to the applicable regulations and standards delineated in Section 1 of the Technical Specification, including but not limited to the applicable regulations of the USCG and ABS.

All fabrications shall be stress-relieved before machining, with base sills machined to 100-Percent (100%) cleanup for simplified installation.

See Section 91 of the Technical Specification for general requirements applicable to motors and controllers.

81.4 ROTARY STEERING GEAR AND STEERING SYSTEMS

81.4.1 General

The steering gear, steering gear pedestal foundation, rudder, rudderstock, rudder trunk, and steering control/monitoring systems shall be purchased as a package from one (1) vendor, with all components fabricated, assembled, painted, pre-wired and tested by the manufacturer, ready for installation by the Shipyard. The same steering system vendor shall have a service facility and field representatives in or within twenty (20) miles of the Puget Sound area on a permanent basis for service and parts.

All electrical cables, interconnecting piping necessary for hydraulic oil transfer between the hydraulic oil reservoir and the fixed storage tank, installation connections, and the alarm annunciators and indicators in each Pilothouse and EOS Control Console are not required to be part of the same vendor package.

The steering systems shall be delivered from the Contractor's vendor complete with all relevant ABS and U.S. Coast Guard compliance certificates. All certificates shall be turned over to the WSF Representative within fifteen (15) days of receipt.

A TENJFORD Model SV650 FCP rotary vane steering gear, or equal, directly attached to the upper end of the rudderstock through a hydraulic SKF-type coupling shall be provided in each End of the Vessel, configured with a high performance flap type rudder at each End (See the *HIGH PERFORMANCE FLAP TYPE RUDDERS* Subsection in Section 2 of the Technical Specification). Each steering gear shall be powered and controlled by dual redundant DANFOSS Model 5032, or equal, variable frequency drives that, in turn, power dual redundant steering motors driving close-coupled vane pumps mounted on the upper housing of the steering gear. There shall be two (2) identical and independent (End No. 1 and End No. 2) steering systems with separate leads to the systems' prime movers (motors) from the source of electric power such that a separate auxiliary means of steering, as otherwise required by regulation, is unnecessary. One (1) steering gear motor in each End shall be powered from the Emergency Switchboard (motor No. 2 and motor No. 4). The other steering gear motor in each End shall be powered from the Ship's Service Switchboard (Motor No. 1 and Motor No. 3). It is the intent that any hydraulic (excluding steering actuator internals), electrical, or control failure of one (1) of the dual redundant steering systems shall not prevent the other system from assuming complete functional control. Each of the dual redundant steering systems shall consist of one (1) electro-hydraulic power unit, variable frequency drive, full follow-up amplifier, full follow-up failure alarm system, power disconnect switch, local control operator, steering gear feeder, and associated controls, alarm circuits, cables and ancillary equipment necessary to make a complete system.

The steering gears, in combination with each steering system, shall provide movement and control of the rudders in accordance with the performance requirements of this Section of the Technical Specification from control stations in the Steering Gear Rooms and each Pilothouse.

Each of the steering gears and related steering systems shall have two (2) independent hydraulic systems (i.e. two (2) systems each end) allowing for seamless transition and continued operation should one (1) hydraulic system, including the related control circuitry, fail.

The steering gears and related control system configurations, excluding the variable frequency drives, require prior proven performance for a double-ended ferry and in accordance with the requirements of Section 50 of the Technical Specification. All components subject to wear, or requiring periodic adjustment or replacement (sensor contacts, filters, etc.) shall be readily serviceable.

See Section 2 of the Technical Specification for rudder requirements.

See Section 4 of the Technical Specification for steering gear assembly removal access hatches in Lower Vehicle deck.

See Section 57 of the Technical Specification for steering gear hydraulic oil storage tank requirements.

See Sections 94 and 99 of the Technical Specification for additional requirements related to the design and installation of the control systems addressed herein.

81.4.2 Required Characteristics

81.4.2.1 Steering Gear Foundation (Pedestal)

1. The steering gear foundation shall be designed and built by the rudder manufacturer to connect the steering gear housing to the rudder trunk. The foundation shall be strong enough to withstand the approximately 867,000 lbs. of radial force transmitted by the rudderstock. The foundation shall be designed and provided with sufficient lightening holes that allow maintenance access and inspection of the rudderstock upper grease seal and the steering unit lower oil seal.

81.4.2.2 Steering Gear

1. The units shall be TENFJORD Model SV650 FCP rotary vane, or equal.

2. The rotary vane unit must be capable of handling the expected 867,000 lb. radial force. The spherical internal surfaces of the unit shall allow for minor misalignment of the rudderstock in the rudder trunk due to wearing of the lower rudderstock bearing.

3. Hard stops that mechanically limit maximum rudder travel shall be integral within the unit, (i.e., no external hard stops allowed).

4. Each steering gear unit shall be powered by dual redundant variable frequency controlled steering motors and close-coupled vane pumps mounted on the upper housing.

5. Operation of the steering pumps and drives shall be such that a failure of the hydraulic power unit in service, including a hydraulic oil leak, shall not prevent the redundant unit from assuming immediate control, thus allowing the Vessel to remain in service pending repairs to the faulted power unit, or related hydraulic piping.

6. Each of the four (4) steering motors (two each end) shall be operated by a DANFOSS Model 5032, or equal, variable frequency drive. This feature shall:

    a. Allow the steering motors to rotate only when commanded to move the rudder allowing for motors that run approximately 15-percent (15%) of the time in normal service, thus extending the maintenance

interval of the pump and motor and allowing the hydraulic oil to run at ambient temperature.

b. Allow the steering motors to reverse direction of rotation when moving the rudder from right to left or left to right.

c. Provide for a soft-start capability, i.e. eliminate the "bang-bang" effect of a two-stage continuously operating pump and also eliminate the complication of a variable displacement pump.

d. Eliminate the need for most of the usual hydraulic control valves (4-way valves, brake valves, counterbalance etc.) reducing maintenance and spare parts, while increasing reliability.

e. Position the rudder with accuracy in the range of 0.2 degrees of travel allowing for better repeatability and allowing for rudder positioning within ½ degree of commanded angle.

7. The design shall make it possible to replace the upper and lower oil seals without disturbing the steering gear housing.

8. The steering units' manufacturer shall provide a stainless steel dual-chamber hydraulic oil head tank and supply the Shipyard with design criteria for the make-up oil tank, hand transfer pump, and interconnecting piping.

9. It shall be possible to move the rudder from thirty-five (35) degrees one side to thirty (30) degrees on the other side with the Vessel running ahead at its maximum speed in no more than fourteen (14) seconds.

81.4.2.3 Steering Control and Transfer System

1. Each of the two (2) Pilothouses shall have full follow-up (FFU) and non-follow-up (NFU) control of both rudders.

2. The FFU levers shall be individual units (not mounted on a common shaft) and arranged fore and aft on the Pilothouse Control Console. The bow rudder (forward) lever shall point toward the bow and the stern rudder (aft) lever shall point toward the stern when the rudders are amidships. The lever length shall be at least six (6) inches. FFU controls shall be provided with a center rudder position detent.

3. The NFU levers shall be arranged similar to the FFU levers. The lever length will be shorter than the FFU levers for ease of identification.

4. The NFU system in each Pilothouse shall control its respective rudder whenever the selector switch for that rudder is moved from FFU to NFU. This means NFU control of the rudder can be initiated even in the Pilothouse not in command of FFU control.

5. It shall be possible to control the rudder from either Steering Gear Room by first rotating a three-position selector switch in a Steering Gear Room from "P/H CONTROL", through center "OFF" position to "LOCAL CONTROL", and then moving an NFU lever right or left while observing a steering gear manufacturer-supplied protractor and pointer assembly affixed to the top of the rudderstock.

6. Each Pilothouse shall have a 5½ inch × 5½ inch bow and stern rudder angle indicator (RAI) mounted in each Pilothouse Control Console, and a color flat screen readout or panorama RAI for the stern rudder mounted in the overhead of each Pilothouse. Final locations of control console mounted RAI and the flat screen readouts or panorama RAI shall be approved by the WSF Representative

7. There shall be a Pilothouse-to-Pilothouse FFU Steering Control Transfer System supplied by the steering gear manufacturer with the following performance characteristics:

    a. It shall be possible to make the transfer by operating a "TRANSFER" switch in the Pilothouse in command combined with operating an "ACKNOWLEDGE" switch in the Pilothouse receiving control.

    b. It shall be possible to make the transfer with the four (4) FFU levers in any position, (i.e. it is not necessary to center both rudders prior to control transfer).

    c. The Control Transfer System shall be designed so that when the acknowledging Pilothouse receives control, the bow rudder on the receiving Pilothouse shall self-center and also lock out control from the bow FFU lever. To restore control to the bow FFU lever, the operator must first center the lever and then depress an "UNLOCK" switch button. The "UNLOCK" switch shall be a dimmable LED lighted switch which remains lit until the switch is depressed. In addition, a pushbutton switch shall be installed adjacent to the "UNLOCK" SWITCH. Its function shall be to center the bow rudder and lock out the bow FFU lever by operator intervention.

    d. Indicator lamps on each Pilothouse Control Console shall show which Pilothouse is in command of the FFU steering system.

8. Steering system shall be capable of outputting and integrating all regulatory required signals to the Vessel's Owner - Furnished Equipment (OFE) Alarm and Monitoring System (AMS). In addition, each of the four (4) control transfer circuits shall alarm separately in the EOS upon fault.

9. There shall be separate and independent FFU and NFU systems, including the FFU amplifiers, lever input potentiometers, rudder feedback potentiometers, FFU control transfer circuits, and FFU Failure Alarm circuits associated with each of the dual redundant steering systems (four (4) total). The FFU and NFU levers in each Pilothouse Control Console shall not be duplicated to accomplish this redundancy.

81.4.3 Equipment Performance

Each steering gear shall move its associated rudder as set forth in the *Required Characteristics* Subsection above. Full rudder movement shall be forty-two (42) degrees to port and starboard, with internal design limits at forty-four (44) degrees port and starboard. The Steering Gear shall also be able to return the bow rudder to the zero (0) degree position from at least twelve (12) degrees port or starboard at the maximum ahead trial speed.

The bow rudder shall have auto-centering capability when the Pilothouse is in command and the bow rudder is in the locked condition. The angle at which the rudder starts auto-centering itself shall be adjustable between ½ degree or less and shall be set during Sea Trials by the steering system supplier.

81.4.4 Steering Equipment: Steering Gear Compartment Location

A single rotary type rudder actuator shall be provided in each Steering Gear Room mated to a high performance flap type rudder as set forth in Section 2 of the Technical Specification.

The two (2) separate electro-hydraulic power units (HPUs) shall be mounted on the top of the rotary rudder actuator. A stainless steel hydraulic oil reservoir and fixed storage tank shall be provided in each Steering Gear Room. Each reservoir and storage tank shall be sized and located to meet manufacture's design requirements for the operating steering system under the highest anticipated ambient temperature of the space without using an oil cooler.

Each HPU shall be a vane pump capable of delivering design flow and pressure in either direction of rotation as marketed by ROLLS-ROYCE MARINE AS, or equal, and providing smooth acceleration and deceleration of the rudders regardless of the pressures required to accomplish maximum rudder torque. Systems employing pressure

compensating pumps, poppet valves, and/or "bang-bang" on-off valving arrangements **do not** constitute systems fulfilling these requirements and **will not** be considered acceptable "or equal" substitutes for the smooth power transmission system described herein.

Each HPU shall have the capacity of a main steering gear, as defined by regulation. The hydraulic circuit shall conform to applicable ABS and USCG requirements. The HPUs and associated electric motors shall be rated at approximately twenty-seven (27) HP, unless calculations performed in the course of design indicate that more power is required to fulfill the capacity and performance requirements stated above, in which case larger units shall be provided.

Each steering gear hydraulic oil reservoir and storage tank shall have access for clean out and a sloping bottom with threaded valve and capped drain plugs at the lowest point. Each reservoir shall have alarm level sensors (see Reference (81B)) attached to the tank top using removable fittings for easy service and testing, sight level gages, filler breathers, temperature gage (oil reservoir only), and fill ports. All filters shall be mounted external to the tank or on the rotary rudder actuator for ease of servicing.

The systems' maximum allowable operating pressure (MAWP) shall be approximately 1,450 psi.

Each steering gear pump motor controller shall contain a disconnect switch, isolation control circuit transformer, low voltage release with memory, and all alarm relays, sensor terminals and fuses related to its steering system, all pre-wired in its own NEMA-12 enclosure. There shall be "START/STOP" push-buttons in each controller along with indicator lights for "POWER AVAILABLE" and "RUN" status. All fusing for the control circuits and various components shall be included. It is intended in normal operation that all four (4) HPU's are in service, (i.e. none are in "STANDBY" mode). Each controller shall have extra terminal space for all steering related connections.

There shall be one (1) pre-wired steering transfer assembly mounted in the steering gear compartment for switching between "LOCAL CONTROL", "OFF", and "REMOTE CONTROL". The local control shall be for the steering gear at that particular End of the Vessel only, such that the Pilothouse in command will still maintain FFU and NFU control of the rudder not in local control.

There shall be one (1) dual circuit non-follow-up (NFU) jog steering controller mounted in each steering gear compartment.

The steering gear control system shall include a watertight rudder feedback control unit with dual cam adjustable limit switches, dual independent feedback and dual lever input devices for the follow-up steering amplifiers, rudder angle amplifiers, and dual independent feedback devices and dual lever input devices for the follow-up failure alarm. The interconnecting link shall be chain drive.

All electrical enclosures that are part of the steering system in the Steering Gear Rooms shall be fitted with electric anti-condensation heaters.

One (1) aluminum mechanical type rudder angle indicator, with a pointer showing degree of rudder angle shall be provided in each Steering Gear Room. A reflective tape scale shall be mounted adjacent to the engraved scale. Engraving on the aluminum scale shall be as set forth in Section 24 of the Technical Specification, but filled with bright "WHITE" enamel for visibility in low light.

All switches for each of the redundant steering control systems shall be in separate enclosures or separated by approved fire-resistant barriers.

81.4.5 Steering Equipment: Engineer's Operating Station Location

The following ***alarms, indicators,*** *and* ***controls*** shall be incorporated into the EOS for the system at each End:

81.4.5.1 Steering Alarms

There will be an Owner - Furnished Equipment (OFE) Alarm and Monitoring System (AMS) installed in the EOS (see Reference (81A)), complete with user-interface displays mounted on the EOS Control Console. The Shipyard's steering gear sub-contractor shall provide the Steering Gear Alarm System. The steering gear sub-contractor shall coordinate with the Propulsion System Integrator (PSI) Contractor to provide a seamless interface between the steering gear sub-contractor provided alarm system and the PSI Contractor provided AMS. The steering gear alarms shall enunciate at the PSI Contractor provided AMS, and shall be acknowledged and silenced via the PSI Contractor's AMS. The intent is to be able to monitor, silence, and acknowledge all alarms in one (1) location. steering gear alarm inputs for use by the PSI Contractor provided AMS are listed in the Propulsion System Contract - Alarm & Monitoring Points List in Reference (81A)). Any other alarms deemed pertinent to the designed steering system shall also be provided.

81.4.5.2 Steering Indicators

There shall be steering gear pump status indicators on the Pilothouse and EOS Control Consoles indicating pump running and pump stopped for each of the steering gear units.

81.4.5.3 Steering Controls

There shall be push button operators on the Pilothouse and EOS Control Consoles for starting and stopping each of the steering gear units.

81.4.6 Steering Equipment: No. 1 And No. 2 Pilothouse Locations

A single pre-wired Steering Follow Up Failure (FFU) Alarm/Control Panel shall be provided for each Pilothouse Control Console which incorporates the following: "Bow" and "Stern" mode (FFU/NFU) selector switches, Steering Motor Control, and Steering Full Follow-Up Failure Alarm.

Each Pilothouse shall have a steering gear sub-contractor Steering Control/Alarm Panel installed on its Control Console The steering gear sub-contractor shall coordinate with the Propulsion System Integrator (PSI) Contractor to provide a seamless interface between the steering gear sub-contractor provided alarm system and the PSI Contractor provided AMS (see Reference (81A)). All alarms shall enunciate at both the Pilothouse Steering Gear Control/Alarm Panel and the EOS PSI Contractor provided AMS. The Pilothouse alarms shall be capable of being silenced and acknowledged from the Pilothouse Control Console. Pilothouse alarms shall also enunciate at the EOS PSI Contractor provided AMS, and require operator intervention from the EOS to silence and acknowledge these alarms in the EOS. The following alarm and monitoring inputs to the OFE Pilothouse Control/Alarm Panels shall be provided:

81.4.6.1 Steering Alarms

1. STEERING HPU MOTOR OVERLOAD
2. STEERING HPU MOTOR LOSS OF PHASE
3. STEERING HPU POWER FAILURE
4. STEERING CONTROL POWER FAILURE
5. STEERING HPU - LOW OIL LEVEL
6. HIGH PRESSURE LOOP FILTER - HIGH DIFFERENTIAL PRESSURE

81.4.6.2 Steering Indicators

1. STEERING HPU – ON LINE INDICATOR

There shall be a "Steering Transfer Station" panel in each Pilothouse Control Console. Its function shall be to accomplish sequential interlocked transfer of steering control from one (1) Pilothouse to the other. The transfer system shall function as follows:

To initiate a steering transfer from the Pilothouse "in control", a button marked "INITIATE TRANSFER" is pushed. At this time, both a flashing visual and pulsing audible alarm in both Pilothouses will indicate that the steering transfer system is "armed". The Pilothouse "in control" initiated transfer can be canceled by pressing the "ACKNOWEDGE" button in the Pilothouse "in control" prior to the other Pilothouse pressing its "ACKNOWLEDGE" or "completed" by pushing the "ACKNOWLEDGE" button in the opposite Pilothouse. After the "ACKNOWLEDGE" button is pushed, there will be an "electrically proper" transfer

designed to insure that all controls securely transferred before the visual and audible alarms shut off. Only after this, will the visual and audible alarm be silenced. The initiating Pilothouse shall remain in control until the transfer is complete.

NOTE: In addition to its steering function responsibilities above, the Steering Transfer Station panel shall also include contacts and switching to provide "bow direction" switching required for the Universal Automatic Identification System (UAIS) provided in Section 94 of the Technical Specification.

NOTE: The Contractor shall not incorporate the steering unit energizing circuit into the Pilothouse transfer system. Each HPU pump shall have a set of start/stop buttons on each Pilothouse Control Console. The NFU system shall not be part of the Pilothouse transfer circuit, (i.e. the NFU system shall be available whenever it is selected from either Pilothouse. There shall be a Steering Alarm System remote display in each Pilothouse, meeting current U.S. Coast Guard regulations and Section 95 of the Technical Specification).

There shall also be provided an independent Steering Follow-Up Failure alarm for each rudder system, in accordance with current U.S. Coast Guard regulations, located in the alarm panels.

81.4.7 Cleaning and Flushing

The completed hydraulic piping system shall be thoroughly cleaned and flushed of all contaminates in accordance with the requirements of Section 74 of the Technical Specification and the steering equipment manufacturer's recommendations.

81.5 ANCHOR WINCH

An anchor windlass shall be provided in the Anchor Winch area on the Lower Vehicle Deck. The anchor windlass shall be hand crank operated, MARKEY MACHINERY Co., Type WHSD-22, or equal, with galvanized heavy steel frame and drum with the following features:

81.5.1 Capacity

Provide 450 feet of 1⅜ inch diameter steel wire rope, plus twelve (12) feet of 1¼ inch stud link anchor chain. See Section 10 of the Technical Specification.

81.5.2 Drum Barrel

Fourteen (14)inch diameter, minimum.

81.5.3 Pull Capacity

Sized to meet the requirements of the Contractor's design (4,000 lbs. line pull minimum), at average layer of wire, with input effort not to exceed 100 lbs. on fourteen (14) inch radius crank.

81.5.4 Reduction Gears

Shall be cut tooth spur type, fully guarded. Approximately 72 to 1 (72:1) high pull input shaft ratio and 9 to 1 (9:1) fast input shaft ratio.

81.5.5 Drive Cranks

Cranks shall be applicable to input and intermediate shafts, for two (2) drive ratios, and to both ends of each shaft, permitting two (2) man operation.

81.5.6 Brake

Drum shall be provided with a wheel-operated, lined band brake capable of stopping and holding anchor, chain and cable when released with a run.

81.5.7 Holding Pawl

A manually engaged holding pawl shall be fitted with arrangement for line lead from the top of the drum. Gravity ratcheting shall be provided.

81.5.8 Bearings

Heavy duty bronze bushed with greasing provisions.

The Contractor shall design and provide a suitable foundation, see Section 2 of the Technical Specification. The anchor windlass shall be attached to a suitable foundation using Type 304 stainless steel bolts in accordance with the manufacturer's recommendations. Welded steel stop blocks shall be provided on the anchor side of the windlass.

81.5.9 Cover

The Contractor shall provide a light gray canvas cover that protects the anchor winch assembly. It shall be made from 18-ounce HERCULITE, or equal material, sown with nylon thread and supplied with ⅜-inch brass eyelets, and polyester solid braided rope for tie down purposes. The cover shall be easily installed and removed by one (1) person.

Anchor, chain, cable and fittings are specified in Section 10 of the Technical Specification.

See Section 22 of the Technical Specification for additional cover requirements.

81.6 SPARE PARTS AND INSTRUCTION MANUALS

Provide a list of recommended spare parts and special tools for those items which are Contractor furnished, together with parts lists and instruction manuals necessary to maintain and service provided equipment and accessories in accordance with the requirements of Sections 86 and 100 of the Technical Specification.

81.7 TESTS, TRIALS AND INSPECTIONS

Test and/or trials shall be in accordance with this Section and with Section 101 of the Technical Specification.

Inspections shall be performed as defined in this Section and in Section 1 of the Technical Specification.

81.8 PHASE II TECHNICAL PROPOSAL REQUIREMENTS

See Section 50 of the Technical Specification regarding requirements for arrangement of the Steering Gear Rooms.

The following deliverable, in addition to other drawings required by Section 100 of the Technical Specification and the Authoritative Agencies, shall be provided during the Phase II Technical Proposal stage of Work in accordance with the requirements of Section 100 of the Technical Specification:

A. Steering Gear Sizing Calculations

See Section 100 of the Technical Specification for additional requirements regarding technical documentation.

Steering Gear Sizing Calculations shall include maximum rudder torque calculations for both ahead and astern operating modes.

81.9 PHASE III DETAIL DESIGN AND CONSTRUCTION REQUIREMENTS

See Section 50 of the Technical Specification regarding requirements for arrangement of the Steering Gear Rooms.

The deliverables required by Section 100 of the Technical Specification and the Authoritative Agencies, shall be provided during the Phase III Detail Design stage of Work in accordance with the requirements of Section 100 of the Technical Specification.

The steering gears shall be provided with a bulkhead mounted chart illustrating normal, alternate and emergency (local) operation including the transfer procedures required by Section 24 of the Technical Specification.

See Section 100 of the Technical Specification for additional requirements regarding technical documentation.

(END OF SECTION)